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# AGRICULTURAL DIVERSIFICATION FOR COTTON GROWING AREAS IN BUGANDA REGION USING LINEAR PROGRAMMING

by

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The undersigned certify that they have read and recommend to the Chairman of the Department of Rural Economy, for acceptance, a project paper entitled "Agricultural Diversification for Cotton Growing Areas in Buganda Region Using Linear Programming" submitted by Andrew Jasper Kaggwa in partial fulfillment of the requirements for the Degree of Masters of Agriculture.

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# INTRODUCTION

Insufficient diversification is one of the characteristics of most under-developed economies. Even in a single industry such as agriculture neither the producer nor the consumer have enough alternative opportunities for economic pursuits. This phenomenon is manifested in a traditional pattern of production, distribution, consumption and resource allocation such that production cannot keep pace with the ever changing social, economic and technological systems of a region or country.

In Buganda region there are certain areas which up to now have depended on cotton production as the only source of farm income.[1] Production of any other cash crop is very minimal. Furthermore, cotton production in these areas has been declining over the last ten years. This situation has led to an economic stagnation of the area. In real terms, net farm incomes are not only low, they are generally decreasing. Moreover, incomes based on cotton production tend to fluctuate from time to time because of the instability of the world market for the crop. Consequently, farm incomes tend to lag behind non-farm incomes. This situation retards

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[1] Mubende district and some other areas of West Buganda are being referred to here in particular.

the growth of agriculture as an industry within the country.

These cotton growing areas merit policies designed to promote other farm products of high economic value. Fortunately the region has fertile soils, favourable climatic conditions and market potentials which can support a more diversified agricultural system if certain constraints are eased.

Diversification has been advocated as a way to reduce vulnerability of farm incomes.[1] Risks and uncertainities can also be reduced with increased diversity in the production system. A number of writers have already dealt with the evils of limited diversity in a growing economy (Oloya and others listed in the bibliography). What these writers say is that low and fluctuating farm incomes are sustained by undiversified agricultural systems in developing countries.

Specialization is not economically viable in a region where certain economic conditions are lacking. Raan Weitz [18] who speaks about three stages of development, namely subsistence, diversification and specialization observes that in order for specialization to be successful the following conditions need to be present:

(1) Mechanization of the production process to ensure steady and standardized production.

---

[1] Among attempts to remedy the effects of price fluctuations in Uganda are the use of marketing boards, promotion of non-agricultural industries such as tourism, agricultural diversification and use of world commodity agreements.

(2) Growing demand for the specialized product.

(3) Marketing facilities such as transportation, financing institutions and other overheads.

These conditions could be expected to evolve during stages of diversification away from subsistence, as Weitz suggests. Diversified farms can survive unstable demand conditions, unreliable market services and slow mechanization by spreading risk among enterprises. In the case of Buganda region pre-independence specialization in cotton has put cotton growers in a vulnerable position. That is to say, following the Weitz argument, Buganda farm development has jumped from subsistence to precarious specialization without the necessary intermediate step of diversification.

Another observer [15] noted that while cotton prices seem to have some prospects for stability, large scale expansion of cotton production is at the present time limited by several factors including:

(1) Competition with other world cotton suppliers, particularly the U.S.A.

(2) Absence of prospects for an international agreement for cotton.

(3) Ineffective method of land hoeing limiting increase in acreage.

(4) Absence of mechanical harvesting facilities.

If the objective of agricultural policy is to increase production and improve incomes in the face of these limiting factors then a move away from a mono-cultural type of pro-

duction at this stage of development seems called for. A number of farm production activities which can take advantage of some growing and different markets should be promoted.

Since the first Five Year Development Plan of 1961/62 to 1965/66, it has been a policy to diversify agricultural production throughout the country by promoting various farm products such as dairy cattle, kenaf, jute, cacao, vanilla and others. The procedure has been to make available to farmers inputs and advisory services required for these relatively new farm enterprises.

Various diversification projects which are listed in Appendix III have a tendency to result in specialization at the farm level. New farm activities emerge as the only source of income once they are adopted. There is a possibility that average farmers who will adopt activities such as dairy cattle production, jute, cacao or oilseeds will end up replacing cotton with just another crop or livestock activity. That way the actual problem of over-dependency within the farm unit cannot be removed. This tendency is possible because of the lack of adequate infrastructure in the region, limited profitability of other farm production activities, competition for farm resources and management capacity of farmers.

Although a number of farmers in the region have abandoned cotton, alternative sources of farm income are very limited. Most of the crops grown in the area are consumed on the farms and tend to have low commercial values because

of the limited market facilities, perishability and bulkiness of the vegetables, roots, tubers and fruits which most farmers grow.

So far no programme has been designed for such areas to give farmers indication of the most profitable combination of farm activities. Each activity is treated as if it is independent of the rest on the use of farm resources and market prospects. As decision makers farmers should be informed of what can happen to the level of net income when different combinations of farm activities are undertaken. Also levels of resource use and profitability of alternative farm enterprises should be made clear to the decision makers.

Achieving diversification in a region is to encourage each individual farm to have a combination of different production activities instead of having each farmer specialize in a different cash production activity hoping that the total regional production will be diversified. To enable farmers to adopt several new farm activities, there should be ways of selecting the most profitable combination of crop and/or livestock enterprises from among a number of possible alternatives. The alternatives must be economically interesting and farmers must have opportunities to ease resource constraints.

This study is designed to explore ways of determining profitable combinations of farm activities based on a representative average size farm. The policy instruments focus on the economic incentives which can stimulate and maintain

production of a number of crops and/or livestock types of farm outputs. Indigenous production activities and practices which can easily be modified by the farmers in the region form the basis of the analysis. The aim is to enable each farm in the region to have more than one major source of income.

Linear programming is the technique chosen for this kind of analysis. A representative farm approach is used to create a basic solution specializing in cotton, which indicates the type of policy instruments for a more diversified solution. Using this model as a basis, policy instruments are subsequently introduced and tested for effectiveness.

# DESCRIPTION OF THE MODEL FARM USED IN THE ANALYSIS

A linear programming model is used here to represent a typical average farm in Mubende district and other cotton growing areas of Buganda region. The size of a typical farm[1] is 1.5 hectares, 0.1 of which is devoted to plantain, the staple food crop. The rest of the land is used for growing cotton and a few other perennial crops. From year to year the land which is not under plantain can be expanded for some annual crops to meet family needs. Subsistence crops are usually grown on a very small scale and they are rarely used as source of income. Cotton tends to be the only cash crop while plantain, sweet potato and vegetables are used for food purposes.

Breaking new land is a labour intensive activity often requiring hired labour and sometimes supplemented by tractor services. Two qualities of soil are distinguishable on most typical plots in the region. In the model they are designated as types "A" and "B" where type A is more fertile than B. The former is softer, less stony and less rain

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[1] The parameters of a typical farm are selected on the basis of reasonableness and convenience, recognizing the arbitrariness of the concept of a typical farm, and lack of suitable data at the University of Alberta.

packed than type B.

The model considers 15 production activities from which a combination can be selected for the purpose of maximizing net profit. The products are plantain, banana, maize, sweet potatoes, vegetables, cotton, coffee, poultry, castor seed, cassava, beef cattle, goats, pigs and weaners.

Also in the model it is assumed that on the farm there are three adults and the total number of working days available during the crop year is 546.0. The availability of labour at the right time during the year is grouped into three separate season; from January through April 180 man-days are available, from May through August 186 and for the rest of the year 180 man-days. Consideration is taken for other non-farm activities and rainy days during which no work can be done.

A linear programming model is made out of rows and columns of coefficients. In this particular model the coefficients are determined by estimating resource requirements for each of the 15 alternative activities for a plot of 0.1 hectares. Marginal yields and values for all products are estimated and the resultant rows and columns of coefficients are referred to as activities. Detailed descriptions of the alternative farm activities are found in Appendix I.

Each of the constraining resources is indicated by its maximum available physical amount which is listed in the column designated Right Hand Side in the model. Production

of the most profitable activities can expand until at least one limiting resource is used up.

Development activities in the farm model are provided to explore the effects and policy requirements of the limiting resources. Land, labour and capital resources can be expanded using the development activities in as much as it is profitable to do so. The development activities include breaking land and using hired labour and tractor services. Hired labour is obtainable at a cost of 3.50 shillings per man-day. Tractor services can also be hired at 60.00 shillings per tractor hour.

The average farm endowment is estimated as:

| Resource | Value or Amount |
|---|---|
| Land Type A | 1.00 hectare |
| Land Type B | 0.50 hectare |
| Labour | 546.00 man-days |
| Capital | 150.00 shs. |
| Transport | 60.00 shs. |
| Tractor Service | 10.00 tractor hours |
| Storage | 100.00 shs. |

where capital, transport and storage are expressed in monetary units as a convenient measure to express their relative scarcity. It is presumed that even if a farmer can afford to pay for an item like transportation, it may not be available when required. The availability of such services at

the right time causes limitations on farm production. Estimation of their value is therefore meant to reflect such limitations rather than actual budgeted sum for each item. In addition to that farm endowment, a cotton subsidy programme also impinges on the farmer's decisions. The effect of this policy programme is shown as a separate activity designed as cotton subsidy (CSUBSDY) in the model.

A profit maximization model is then built on the above factors which are converted into coefficients. The coefficients form matrices which can be operated on using mathematical tools in order to arrive at a basic solution. The assumptions behind the model are that:

(1) There is a linear relationship between activities and the net revenue function.

(2) If inputs of an activity are doubled, output is also doubled. This attribute is termed "proportionality".

(3) All bits of a single resource used by different activities add up to the total physical amount of the resource being employed; hence the term "additivity".

(4) There can be no negative physical amount of any resource or product. This assumption is termed "no negativity".

The existence of these assumptions indicate that the solution can only approximate a reality. For this reason one can only make the best use of the solution with refer-

ence to ranges within which real facts may lie. Range analysis in the solution indicates the variations over which physical inputs and/or outputs can change before the net revenue is altered. The solution elaborates the following type of information:

(1) Optimum net revenue from a one year crop operation of a representative farm.

(2) The most profitable combination of alternative farm enterprises for the region.

(3) Amounts of each resource needed to maximize farm profits.

(4) Optimum level of production for each alternative enterprise.

(5) Different constraints and their intensities.

(6) Changes which can be made to the net revenue and to the relative profitability of each farm activity by altering prices or availability of inputs.

# THEORETICAL ASPECT OF THE MODEL

A linear programming model is a set of equations which can be expressed algebraically in the following manner:

$Z = Px$ (objective function)

$L = Ax$ (constraining function)

$x \geq 0$ (conditional element)

where Z is the net revenue, P is the net value of production, L is the quality of resource to be used and A is the technical coefficient which represents the rate at which resources are used up by individual farm activities. The level at which the activities x can optimize the objective function is determined by the specifications of A and P. Diagram 1 represents the model which is completed by including in it rows for accounting purposes. These rows are designated I, G and V to represent inventories of products, government policy effects and market values of each product, respectively. Development and policy activities are included as separate columns. The column designated RHS represents the farm's resource constraints or their upper limits.

The objective of the model is to maximize the value of Z. The equations can be arranged as in the Diagram but

# DIAGRAM 1

## THE GENERAL FORM OF MATRICES FOR THE MODEL FARM ACTIVITIES AND RESOURCES

| Production 15 Columns | | Selling 14 Columns | | Policy 5 Columns | | Development 8 Columns | | | |
|---|---|---|---|---|---|---|---|---|---|
| Cx | + | Py | + | gz | + | dv | = | Z | objective; net revenue |
| ax | + | ay | | | + | av | ≤ | L | resources (10 rows) |
| 1x | - | 1y | | | | | = | 0 | commodity balances (11 rows) |
| fx | | | - | fz | | | = | 0 | accounting balances for policy effect (1 row) |
| | | Wy | | | | | = | V | value added (1 row) |

C = Cost of production.
x,y,z,v = Levels at which column activities optimize net revenue.
P = Price.
g = Government policy impact on net revenue.
d = Development activity costs.
a = Resources used per unit of various activities.
1 = Physical account of production.
f = Accounting coefficients for government interventions.
W = Value of production per unit of commodity sold.

TABLE 1

INPUT AND OUTPUT COEFFICIENTS FOT THE ALTERNATIVE ACTIVITIES

(RESOURCE REQUIREMENTS PER ACTIVITY ON THE MODEL FARM)

| BOUND | PLANTN LOWER | BANANA LOWER | POTATO LOWER | VEG LOWER | COTT LOWER | COFF LOWER | MAIZE LOWER | CASSV LOWER | 1....1 BOUND |
|---|---|---|---|---|---|---|---|---|---|
| NETREV | 3.00000- | 3.00000- | 11.20000- | 11.50000- | 7.70000- | 9.00000- | 9.00000- | 9.00000- | NETREV |
| LANDA | .10000 | . | . | .10000 | .10000 | .10000 | .10000 | . | LANDA |
| LANDB | . | .10000 | .10000 | . | . | . | . | .10000 | LANDB |
| LABJ-A | .10000 | .10000 | 5.00000 | 15.00000 | 12.00000 | 10.00000 | 15.00000 | 10.00000 | LABJ-A |
| LABM-A | .10000 | .10000 | 5.00000 | 20.00000 | 2.00000 | 12.00000 | 10.00000 | 6.00000 | LABM-A |
| LABS-D | .10000 | .10000 | 5.00000 | 5.00000 | 12.00000 | 15.00000 | 5.00000 | 12.00000 | LABS-D |
| CAPEQ | .50000 | .50000 | 6.00000 | 6.00000 | 7.50000 | 8.00000 | 3.00000 | 3.00000 | CAPEQ |
| TRACTO | . | . | .30000 | .30000 | .30000 | .30000 | .30000 | .30000 | TRACTO |
| TRANS | 2.00000 | 2.00000 | 5.00000 | 5.00000 | . | . | 5.00000 | 5.00000 | TRANS |
| C-COST | .50000 | .50000 | .20000 | .50000 | .20000 | 1.00000 | 1.00000 | 1.00000 | C-COST |
| INVPLTN | 300.00000 | . | . | . | . | . | . | . | INVPLTN |
| INVBANA | . | 150.00000 | . | . | . | . | . | . | INVBANA |
| INVPOTA | . | . | 80.00000 | . | . | . | . | . | INVPOTA |
| INVVEG | . | . | . | 40.00000 | . | . | . | . | INVVEG |
| INVCOTT | . | . | . | . | 60.00000 | . | . | . | INVCOTT |
| INVCOP | . | . | . | . | . | 50.00000 | . | . | INVCOP |
| INVMAIZ | . | . | . | . | . | . | 50.00000 | . | INVMAIZ |
| INVCASS | . | . | . | . | . | . | . | 60.00000 | INVCASS |
| GOVT. | . | . | . | . | 7.50000 | . | . | . | GOVT. |

Table 1 Continued...1

| BOUND | PIG<br>LOWER | GOAT<br>LOWER | POUL<br>LOWER | BEEF<br>LOWER | M/VEG<br>LOWER | M/POT<br>LOWER | CASTO<br>LOWER | S.PLTN<br>LOWER | 2....1<br>BOUND |
|---|---|---|---|---|---|---|---|---|---|
| NETREV | 255.00000- | 40.00000- | 390.00000- | 720.00000- | 12.00000- | 12.00000- | 3.40000- | .20000 | NETREV |
| LANDA | .05000 | . | . | .10000 | .10000 | . | .10000 | . | LANDA |
| LANDB | .10000 | .10000 | .01000 | .25000 | . | .10000 | . | . | LANDB |
| LABJ-A | 10.00000 | 10.00000 | 10.00000 | 10.00000 | 17.00000 | 5.00000 | 10.00000 | .10000 | LABJ-A |
| LABM-A | 10.00000 | 10.00000 | 10.00000 | 10.00000 | 11.00000 | 5.00000 | . | .10000 | LABM-A |
| LABS-D | 10.00000 | 10.00000 | 10.00000 | 10.00000 | 13.00000 | 10.00000 | 5.00000 | .10000 | LABS-D |
| CAPEQ | 20.00000 | 20.00000 | 170.00000 | 100.00000 | 6.00000 | 6.00000 | 3.00000 | . | CAPEQ |
| CAPHOU | 10.00000 | 10.00000 | 15.00000 | 10.00000 | . | . | . | . | CAPHOU |
| TRACTO | . | . | . | . | .30000 | .30000 | . | . | TRACTO |
| TRANS | 5.00000 | 5.00000 | 5.00000 | 10.00000 | 5.00000 | 5.00000 | .20000 | . | TRANS |
| C-COST | 220.00000 | 5.00000 | 200.00000 | 600.00000 | 1.00000 | 1.00000 | .20000 | . | C-COST |
| INVPLTN | . | . | . | . | . | . | . | 1.00000- | INVPLTN |
| INVPOTA | . | . | . | . | . | 40.00000 | . | . | INVPOTA |
| INVVEG | . | . | . | . | 20.00000 | . | . | . | INVVEG |
| INVMAIZ | . | . | . | . | 25.00000 | 25.00000 | . | . | INVMAIZ |
| INVPIG | 1.33000 | . | . | . | . | . | . | . | INVPIG |
| INVGOAT | . | .90000 | . | . | . | . | . | . | INVGOAT |
| INVPOUL | . | . | 40.00000 | . | . | . | . | . | INVPOUL |
| INVBEEF | . | . | . | .50000 | . | . | . | . | INVBEEF |
| INVASTO | . | . | . | . | . | . | 80.00000 | . | INVASTO |
| INVWEAN | 2.00000 | . | . | . | . | . | . | . | INVWEAN |
| VALPRO | . | . | . | . | . | . | . | .20000 | VALPRO |

Table 1 Continued...2

```
           S.BANA      S.POTA      S.VEG       S.COTT      S.COFF      S.MAIZ      S.SAVA      S.PIG           3...
BOUND      LOWER       LOWER       LOWER       LOWER       LOWER       LOWER       LOWER       LOWER         BOUND

NETREV       .20000      .80000      .70000     1.33000     1.13000      .75000      .40000   195.00000    NETREV
LABJ-A       .10000     .            .02000    .             .01000      .01000      .05000      .01000    LABJ-A
LABM-A       .10000      .01000      .10000      .02000      .02000     .            .05000      .01000    LABM-A
LABS-D       .10000      .01000     .           .            .01000      .01000      .05000      .01000    LABS-D
CAPHOU      .           .           .            .05000      .05000      .05000     .           .          CAPHOU
TRANS       .           .            .15000      .02000      .02000     .            .10000     5.00000    TRANS
INVBANA     1.00000-    .           .           .           .           .           .           .          INVBAN
INVPOTA     .           1.00000-    .           .           .           .           .           .          INVPOT
INVVEG      .           .           1.10000-    .           .           .           .           .          INVVEG
INVCOTT     .           .           .           1.00000-    .           .           .           .          INVCOT
INVCOF      .           .           .           .           1.20000-    .           .           .          INVCOF
INVMAIZ     .           .           .           .           .           1.00000-    .           .          INVMAI
INVCASS     .           .           .           .           .           .           1.30000-    .          INVCAS
INVPIG      .           .           .           .           .           .           .           1.00000-   INVPIG
VALPRO       .20000      .80000      .85000     1.40000     1.20000      .80000      .50000   200.00000    VALPRO


           S.GOAT      S.POLT      S.BEEF      S.ASTO      S.WEAN      BREAKLA     BREAKLB     HLJ-A          4....
BOUND      LOWER       LOWER       LOWER       LOWER       LOWER       LOWER       LOWER       LOWER         BOUND

NETREV     100.00000    10.50000   1480.0000     .33000    20.00000     5.00000-    5.00000-    3.50000-   NETREV
LANDA       .           .           .           .           .           1.00000-    .           .          LANDA
LANDB       .           .           .           .           .           .           1.00000-    .          LANDB
LABJ-A       .01000      .01000      .01000     .           .           .           7.50000     1.00000-   LABJ-A
LABM-A       .01000      .01000      .01000      .05000     .           7.50000     7.50000     .          LABM-A
LABS-D       .01000      .01000      .01000     .           .           .           .           .          LABS-D
CAPHOU      .           .           .            .05000     .           .           .           .          CAPHOU
TRACTO      .           .           .           .           .           2.00000     4.00000     .          TRACTO
TRANS       5.00000      .50000    20.00000      .02000     .           .           .           .          TRANS
C-COST      .           .           .           .           .           5.00000     5.00000     3.50000    C-COST
INVGOAT     1.00000-    .           .           .           .           .           .           .          INVGOAT
INVPOUL     .           1.00000-    .           .           .           .           .           .          INVPOUL
INVBEEF     .           .           1.00000-    .           .           .           .           .          INVBEEF
INVASTO     .           .           .           1.00000-    .           .           .           .          INVASTO
INVWEAN     .           .           .           .           1.00000-    .           .           .          INVWEAN
GOVTP       .           .           .           1.00000     .           .           .           .          GOVTP
VALPRO     105.00000    11.00000   1500.0000     .40000    20.00000     .           .           .          VALPRO
```

Table 1 Continued...3

```
         MLS-A       MLS-D       CSUBSDY     CREDIT       PSUBSDY     TRANSDY      TRACTS.      MUS1           5....
BOUND    LOWER       LOWER       LOWER       LOWER        LOWER                    UPPER                       BOUND

NETREV    3.50000-    3.50000-    1.00000    30.00000-     .04000       .          60.00000-       .           NETREV
LANDA      .           .           .           .            .           .            .            1.00000      LANDA
LANDB      .           .           .           .            .           .            .             .50000      LANDB
LABJ-A     .           .           .           .            .           .            .          180.00000      LABJ-A
LABM-A    1.00000-     .           .           .            .           .            .          160.00000      LABM-A
LABS-D     .          1.00000-     .           .            .           .            .          180.00000      LABS-D
CAPRO      .           .          1.00000-   70.00000-      .           .            .          150.00000      CAPRO
CAPHOM     .           .           .           .            .           .            .          100.00000      CAPHOM
TRACTO     .           .           .           .            .           .           1.00000-       .           TRACTO
TRANS      .           .           .           .            .         10.00000-      .           60.00000      TRANS
C-COST    3.50000     3.50000      .           .            .           .          60.00000        .           C-COST
GOVTP      .           .           .           .           1.00000-     .            .             .           GOVTP
GOVTT      .           .           .           .            .          1.00000-      .             .           GOVTT
GOVT.      .           .          2.00000-     .            .           .            .             .           GOVT.
```

a detailed set up of the model is in Table 1. Symbols P and A are actually the submatrices of the model. P is a vector ranging from 1 by n including different prices of products. Similarly A matrix is 1 by n including various fixed amounts of each resource for the alternative farm activities.

## THE BASIC SOLUTION

The basic solution represents the farming situation before any diversification programme becomes effective. It brings out the fact that cotton is the dominant cash crop on the average farm in the region. The basic solution is contrived for the purpose of this study by juggling prices, costs, yields and actual definitions of certain production activities.[1]

Net revenue in this solution is 731.00 shillings which is the net value of cotton and other food crops on the farm. The actual cash income from this model farm is 597.00 shillings which is the value of cotton produced in one crop year. More information about the basic solution is summarized in Tables 3 through 11.

Table 2 shows the amounts of each resource required to optimize the net revenue of the farm.[2] Table 3 shows likely production, value and costs which a typical farm can have in a normal crop year.

---

[1] Most of the data for prices and yields were obtained as secondary data from various publications shown in the bibliography. Where specific data for the region were lacking averages for the whole country were used.

[2] Optimum net revenue is the maximum possible revenues this model farm can make out of the existing resources.

## TABLE 2

## RESOURCES REQUIRED IN THE BASIC SOLUTION FOR AN AVERAGE FARM IN BUGANDA COTTON GROWING AREA

| Resources | Units | Available | Used | Idle |
|---|---|---|---|---|
| Land Type A | ha | 1.0 | 0.99 | .01 |
| Land Type B | ha | 0.5 | 0.50 | -- |
| Total Land | ha | 1.5 | 1.49 | .01 |
| Labour: January - April | man-days | 180.0 | 180.0 | -- |
| May - August | man-days | 186.0 | 114.0 | 71.52 |
| September - December | man-days | 180.0 | 180.0 | -- |
| Total Annual Labour | man-days | 546.0 | 474.0 | 71.52 |
| Capital Equipment | sh. | 150.00 | 60.63 | 89.38 |
| Storage | sh. | 100.00 | 23.70 | 76.30 |
| Transport | sh. | 60.00 | 38.48 | 21.52 |
| Recurrent Cash Costs | sh. | No Limit | 249.78 | None |

NOTE: Values in shillings are only used as a convenient expression for the scarcity of the resources rather than actual market values of those resources.

## TABLE 3

## COST AND VALUE OF FOOD AND CASH CROPS ON A NON-DIVERSIFIED FARM IN COTTON GROWING AREAS OF BUGANDA

| Crop | Acreage (ha) | Total Amount Produced/Used | Expected Value (shs) | Gross Value (shs) | Total Cost to Farmer (shs) | Net Value Receivable (shs) |
|---|---|---|---|---|---|---|
| Plantain | 0.20 | 600.0 kg | 0.20/kg | 120.00 | 6.00 | 114.00 |
| Sweet Potatoes | 0.50 | 400.0 kg | 0.80/kg | 320.00 | 56.00 | 264.00 |
| Cotton | 0.79 | 474.0 kg | 1.33/kg | 630.42 | 60.83 | 596.59 |
| Hired Labour | -- | 4.0 M-day | 3.50/M-day | -- | 14.00 | -- |
| Tractor Services | -- | 3.87 T-hr. | 60.00/T-hr. | -- | 232.20 | -- |
| Cotton Subsidy | -- | 29.63 sh. | 1.00/cap. | 29.63 | -- | 29.63 |
| Total | 1.49 | -- | -- | 1100.05 | 369.03 | 731.02 |

Limitations of agricultural diversity are indicated by the low productivity of farm resources as well as low prices for most products. However, the present pattern of production cannot be altered without reducing the levels of income on the average farms, assuming that profitability of all activities remains unchanged. Traditional farm production patterns are expected to be based partly on such limitations.

Table 4 illustrates the comparable profitability of the 15 alternative farm production activities used in the model. Activities with high gross margins are considered first in selecting the combination of activities which can optimize the net revenue. The same table indicates that profitability of these activities can be ranked according to their gross margins for the purpose of selecting the most profitable combination of activities. In the basic solution only the first three production activities are selected. The implication here is that an average farmer is only likely to have a combination of those crops in order to optimize his farm income. The average farmer is therefore not in any position to change the pattern of his farm activities unless there is change in the profitability of the alternative activities or unless there are additional farm resources in the right combination.

## Shadow Pricing, or Dual Activity

In the basic solution shadow pricing indicates what

## TABLE 4

## RETURN PER HECTARE OF LAND FOR EACH ALTERNATIVE FARM ENTERPRISE

(In Shillings)

| Land Type "A" | | Land Type "B" | |
|---|---|---|---|
| Activity | Return Per Hectare | Activity | Return Per Hectare |
| Cotton | 721.00 | Potatoes | 528.00 |
| Plantain | 570.00 | Goats | 500.00 |
| Coffee | 475.00 | Pigs | 443.50 |
| Maize/Vegetables | 387.50 | Poultry | 300.00 |
| Maize | 285.00 | Bananas | 285.00 |
| Castor | 262.20 | Maize/Potatoes | 207.50 |
| Vegetables | 225.00 | Cassava | 210.00 |
| | | Beef | 200.00 |

can happen to the solution when certain alterations are made. For the constraining resources the shadow price is the net farm income foregone if there is a one unit reduction in the availability of a particular resource. If land B is reduced by one hectare, for instance, production would be reduced by 78.96 shillings, which is the shadow price, or marginal value, of the land. An alternative meaning is that by increasing the land by one hectare, net revenue can increase by the amount of the corresponding shadow price because of the increase in output. This kind of information is useful to determine which resources need expansion for purposes of increasing net returns.

The shadow prices for the inventory rows in Table 5 show that if productivity is increased, net revenue can be augmented by the shadow price of the farm product concerned. Productivity can be increased through improved management, a price increase for the output, or a decrease in the cost of farm inputs. In a way shadow prices for final products indicate possible effects of technical improvement so a decision maker can see whether it is possible to improve the situation with the existing resources on the farm.

Resources which do not limit the solution have zero shadow price, which means that change in their availability by a marginal unit does not affect net revenue. Constraining resources exhibit negative shadow prices to show that a reduction in their availability have a negative effect on the objective function.

TABLE 5

SHADOW PRICES FOR LIMITING RESOURCES
USED IN THE MODEL FARM

| Activity | Shadow Price (shs.) |
|---|---|
| Land Type B | 78.96 |
| Labour: January - April | 1.32 |
| Tractor Hire Services | 60.00 |

## Reduced Cost

The real competitive nature of alternative farm activities is shown in the reduced cost section of the solution. It shows amounts by which optimum net revenue can be reduced if an activity is added to the list. Introduction of any new activity on the average farm can reduce the net revenue by a value corresponding to the relevant reduced cost.

The difference between shadow price and reduced cost is that the former deals with resource constraints whereas the latter refers to real production and selling activities of the farm. Shadow pricing indicates possible effects on net revenue of a change in the amount of resource used but it does not show which activities are involved in the process. Reduced cost, on the other hand, deals with activities which are not in the basic solution. If these activities are forced into production on the average farm without

## TABLE 6

## SHADOW PRICES FOR THE 14 PRODUCTS OF THE ALTERNATIVE FARM ACTIVITIES IN THE MODEL

(In Shillings Per Unit)

| | Activity | Shadow Price |
|---|---|---|
| 1. | 1 kg of Plantain | 0.01 |
| 2. | 1 kg of Banana | 0.00 |
| 3. | 1 kg of Potatoes | 0.77 |
| 4. | 1 kg of Vegetables | 0.62 |
| 5. | 1 kg of Cotton | 1.33 |
| 6. | 1 kg of Coffee | 0.90 |
| 7. | 1 kg of Maize | 0.70 |
| 8. | 1 kg of Castor Seed | 0.37 |
| 9. | 1 kg of Cassava | 0.20 |
| 10. | 1 Pig | 194.95 |
| 11. | 1 Goat | 106.78 |
| 12. | 1 Weaner | 20.00 |
| 13. | 1 Cow | 1,479.95 |
| 14. | 1 Chicken | 10.45 |

other changes, the net revenue can fall by the amount shown as reduced cost.

Looking at Table 7 it is possible to determine which activity has the highest likelihood of getting into the optimum solution or being adapted by the average farmer for a given change in profitability. Castor seed and goat production activities have the highest likelihood of entering the optimum solution. These two activities show the lowest reduced cost. Cassava is the least likely to attract farmers as indicated by its highest reduced cost value of 78.15 units. Therefore, if a farmer wishes to increase the number of production activities on his farm, it is most economical, in terms of increasing productivity, to select them in the order listed in Table 7. The shortest route to increasing the variety of farm output from a public policy point of view is also to start with activities which have least reduced cost value. Reduced cost can therefore be used to minimize public expense. For more extended use of both shadow price and reduced cost, sensitivity analysis can be used as demonstrated in the next section.

## Sensitivity Analysis

Sensitivity analysis scrutinizes the basic solution for (a) ranges within which actual prices and yields must exceed before the basic solution can change, and (b) the magnitude of such changes. The usefulness of this type of information is to determine the extent of changes in acti-

## TABLE 7

## REDUCED COSTS FOR COLUMN ACTIVITIES WHICH DO NOT APPEAR IN THE OPTIMUM BASIC SOLUTION FOR THE MODEL FARM

(Shillings Per Unit)

| | Activity | Units | Reduced Cost for Production Activity | Reduced Cost for Selling Activity | Combined Reduced Cost Per Hectare |
|---|---|---|---|---|---|
| 1. | Castor Seed | 0.1 ha | 4.51 | 0.00 | 4.51 |
| 2. | Goats | 1 animal | 0.00 | 6.83 | 6.83 |
| 3. | Pigs | 1 animal | 11.82 | 0.00 | 11.82 |
| 4. | Poultry | 1 bird | 20.93 | 0.00 | 20.93 |
| 5. | Maize | 0.1 ha | 29.22 | 0.00 | 29.22 |
| 6. | Maize/Potatoes | 0.1 ha | 31.36 | 0.00 | 31.36 |
| 7. | Vegetables | 0.1 ha | 42.32 | 0.00 | 42.32 |
| 8. | Coffee | 0.1 ha | 47.63 | 0.00 | 47.63 |
| 9. | Beef | 1 animal | 47.97 | 0.00 | 47.97 |
| 10. | Bananas | 0.1 ha | 11.38 | 42.00 | 53.38 |
| 11. | Maize/Vegetables | 0.1 ha | 68.16 | 0.00 | 68.16 |
| 12. | Cassava | 0.1 ha | 78.15 | 0.00 | 78.15 |
| 13. | Plantain | 0.1 ha | 88.11 | 0.00 | 88.11 |

NOTE: The table shows the order of ease by which production activities can be encouraged into the optimum solution.

vity levels which can lead to a more diversified solution as profitabilities change. Such changes can then be translated into actual policy instruments which can induce average farmers to diversify their production without traumatic effects on their incomes and without degeneration of the solution itself.

Tables 8 to 11 summarize the sensitivity analysis of the basic solution. The following are some of the major findings:

(1) The fact that most production activities are limited by their selling indicates that low yields and/or prices on typical farms are responsible for agricultural stagnation in the region.

(2) Expansion of farm resources such as land and labour is not likely to change the situation as much as increased productivity would.

(3) Limited transport and tractor services tend to be the ultimate barriers to expansion of production on average farms in this region.

(4) A number of food crops can be expanded substantially even when their prices are only increased slightly.

The sensitivity analysis therefore indicates the kind and level of government intervention required to promote more farm production activities for diversification purposes. With this type of information a programme for a diversified farm enterprise can be worked out and tested before imple-

# TABLE 8

## SENSITIVITY ANALYSIS FOR THE LIMITING RESOURCES

## AND ALL INVENTORIES ON THE MODEL FARM

```
NUMBER  ...ROW..  AT  ...ACTIVITY...  SLACK ACTIVITY  ..LOWER LIMIT.  LOWER ACTIVITY  ...UNIT COST..  ..UPPER COST..  LIMITING  AT
                                                      ..UPPER LIMIT.  UPPER ACTIVITY  ...UNIT COST..  ..LOWER COST..  PROCESS.  AT

    3   LANDB     UL        .50000          .                   NONE          .47600       78.95833-                  LANDA     UL
                                                              .50000          .97622       78.95833                   TRANS     UL

    4   LABJ-A    UL     180.00000          .                   NONE       176.00000        1.32083-                  HLS-D     LL
                                                           180.00000       181.20000        1.32083                   LANDA     UL

    6   LABS-D    UL     180.00000          .                   NONE       INFINITY-        3.50000-                     NONE
                                                           180.00000       184.00000        3.50000                   HLS-D     LL

    9   TRACTO    UL            .           .                   NONE         6.13000-      59.99998-                  TRACTSV   UL
                                                                 .           3.87000       59.99998                   TRACTSV   LL

   12   INVPLTN   EQ            .           .                    .         600.00000-        .01161                   PLANTN    LL
                                                                 .          30.25209         .01161-                  LANDA     UL

   14   INVPOTA   EQ            .           .                    .        7151.99609-        .76500                   LABJ-A    UL
                                                                 .         400.00000         .76500-                  HLS-D     LL

   15   INVVEG    EQ            .           .                    .         159.94591-        .61235                   TRANS     UL
                                                                 .               .           .61235-                  S.VEG     LL

   16   INVCOTT   EQ            .           .                    .        1075.99976-       1.33000                   TRANS     UL
                                                                 .         474.00000        1.33000-                  S.COTT    LL

   17   INVCOP    EQ            .           .                    .        1359.15747-        .90149                   TRANS     UL
                                                                 .               .           .90149-                  S.COPP    LL

   18   INVMAIZ   EQ            .           .                    .        1606.31543-        .70179                   CAPROD    UL
                                                                 .               .           .70179-                  S.MAIZ    LL

   19   INVCASS   EQ            .           .                    .         294.48413-        .19920                   TRANS     UL
                                                                 .               .           .19920-                  S.CSVA    LL

   20   INVPIG    EQ            .           .                    .           4.30486-      194.95178                   TRANS     UL
                                                                 .               .         194.95178-                 S.PIG     LL
```

Table 8 Continued...

```
21  INVGOAT   EQ        .          .          .            .         106.78239                   GOAT      LL
                                                .       4.50000        106.78239-                  POTATO    LL

22  INVPOUL   EQ        .          .          .      43.12624-          10.45179                   TRANS     UL
                                                .            .          10.45179-                  S.POULT   LL

23  INVSHEP   EQ        .          .          .       1.07605-        1479.95166                   TRANS     UL
                                                .            .        1479.95166-                  S.SHEP    LL

24  INVASTO   EQ        .          .          .    1075.99976-            .37000                   TRANS     UL
                                                .            .            .37000-                  S.ASTO    LL

25  INVWEAN   EQ        .          .          .      INFINITY-          20.00000                     NONE
                                                .            .          20.00000-                  S.WEAN    LL

26  GOVTP     EQ        .          .          .      INFINITY-            .04000                     NONE
                                                .            .            .04000-                  PSUBSDY   LL

28  GOVT.     EQ        .          .          .      INFINITY-            .50000                     NONE
                                                .     59.25000            .50000-                  CSUBSDY   LL
```

# TABLE 9

## SENSITIVITY ANALYSIS FOR PRODUCTION ACTIVITIES

## WHICH DO NOT OPTIMIZE THE NET REVENUE

```
NUMBER  .COLUMN.  AT  ...ACTIVITY...  ..INPUT COST..  ..LOWER LIMIT.  LOWER ACTIVITY  ...UNIT COST..  ..UPPER COST..  LIMITING  AT
                                                      ..UPPER LIMIT.  UPPER ACTIVITY  ...UNIT COST..  ..LOWER COST..  PROCESS.  AT

    31  BANANA    LL        .             3.00000-         .                .            11.37792       INFINITY-    INVBANA   UL
                                                            NONE            .            11.37792-       8.37792     INVBANA   UL

    33  VEG       LL        .            11.50000-         .                .            42.31856       INFINITY-    S.VEG     LL
                                                            NONE         .37288          42.31856-      30.81856     ULS-D     LL

    35  COFF      LL        .             9.00000-         .                .            47.63367       INFINITY-    S.COFF    LL
                                                            NONE         .75789          47.63367-      38.63367     LANDA     UL

    36  MAIZE     LL        .             9.00000-         .                .            29.22292       INFINITY-    S.MAIZ    LL
                                                            NONE         .40000          29.22292-      20.22292     ULS-D     LL

    37  CASSV     LL        .             9.00000-         .                .            78.15224       INFINITY-    S.SAVA    LL
                                                            NONE        5.00000          78.15224-      69.15224     POTATO    LL

    38  PIG       LL        .           255.00000-         .                .            11.81828       INFINITY-    S.BEAN    LL
                                                            NONE        1.21617          11.81828-     243.18172-    LANDA     UL

    40  POUL      LL        .           390.00000-         .                .            20.92624       INFINITY-    S.POLT    LL
                                                            NONE         .53741          20.92624-     369.07376-    [illegible] UL

    41  BEEF      LL        .           720.00000-         .                .            47.97202       INFINITY-    S.BEEF    LL
                                                            NONE         .08279          47.97202-     672.02798-    LANDA     UL

    42  M/VEG     LL        .            12.00000-         .                .            68.16240       INFINITY-    S.MAIZ    LL
                                                            NONE         .91667          68.16240-      56.16240     ULS-D     LL
```

### Table 9 Continued...

```
43  M/TOT    LL        .            12.00000-       .                       31.35519       INFINITY-  S.MAIZ    LL
                                                    NONE        5.00000     31.35519-      19.35519   POTATO    LL

44  CASTO    LL        .             3.40000-       .           .            4.50833       INFINITY-  S.ASTO    LL
                                                    NONE         .60000      4.50833-       1.10833   LANDA     UL

45  S.PLTN   LL    600.00000          .20000    600.00000     580.11050       .29369       INFINITY-  LANDA     UL
                                                    NONE     1544.85034       .29369-        .49369   COTT      LL

46  S.BANA   LL        .              .20000        .           .             .28208       INFINITY-  INVBANA   UL
                                                    NONE        .             .28208-        .48208   INVBANA   UL

54  S.GOAT   LL        .           100.00000        .           .            6.83062       INFINITY-  GOAT      LL
                                                    NONE        4.50000      6.83062-     106.83062   POTATO    LL

59  BREAKLA  LL        .             5.00000-       .            .01000-   124.99998       INFINITY-  LANDA     UL
                                                    NONE        3.06500    124.99998-     119.99958   TRACISV   UL

60  BREAKLB  LL        .             5.00000-       .            .02087-   175.94791       INFINITY-  LANDA     UL
                                                    NONE         .48633    175.94791-     170.94791   TRANS     UL

61  HLJ-A    LL        .             3.50000-       .           4.00000-     2.17917       INFINITY-  HLS-L     LL
                                                    NONE        1.20000      2.17917-       1.32083-  LANDA     UL

62  HLM-A    LL        .             3.50000-       .          71.36571-     3.50000       INFINITY-  C-COST    LL
                                                    NONE        INFINITY     3.50000-        .            NONE

65  CREDIT   LL        .            30.00000-       .           1.27678-    30.00000       INFINITY-  CAPEQ     UL
                                                    NONE        INFINITY    30.00000-        .            NONE

67  TRANSDY  EQ        .               .            .           2.15200-      .            INFINITY-  TRANS     UL
                                                                              .            INFINITY   GOVTT     LL
```

## TABLE 10

## SENSITIVITY ANALYSIS FOR RESOURCES WHICH ARE NOT SCARCE ON THE MODEL FARM.

```
NUMBER  ...ROW..  AT  ...ACTIVITY...  SLACK ACTIVITY  ..LOWER LIMIT.  LOWER ACTIVITY  ...UNIT COST..  ..UPPER COST..  LIMITING  AT
                                                      ..UPPER LIMIT.  UPPER ACTIVITY  ...UNIT COST..  ..LOWER COST..  PROCESS.  AT

     2  LANDA     BS          .99000          .01000            NONE        2.07500-      124.99998-                  BREAKLA   LL
                                                             1.00000        1.19633       189.50000-                  LANDB     UL

     5  LABR-A    BS       114.48001        71.51999            NONE      113.40801         1.76772-                  LANDB     UL
                                                           186.00000      128.84634         2.13957-                  S.GOAT    LL

     7  CAPEQ     BS        60.62502        89.37496            NONE       INFINITY-         .42657-                  CREDIT    LL
                                                           150.00000      212.85420          .12583-                  POUL      LL

     8  CAPHOU    BS        23.70001        76.29999            NONE       22.70001         5.20333-                  LABR-A    UL
                                                           100.00000       67.43875          .70276-                  S.GOAT    LL

    10  TRANS     BS        38.48001        21.51999            NONE       37.40001         1.75463-                  LANDB     UL
                                                            60.00000       51.11456          .89010-                  POUL      LL

    11  C-COST    BS       249.78000       249.78000-             .        230.30002          .13866-                  CASTO     LL
                                                                NONE      482.55144          .06175-                  PIG       LL
```

mentation. Such a programme can be self-sustaining because of the economic incentives on which it is built.

This analysis indicates diversification through increased productivity and economic incentives. The idea is to introduce diversification on the individual farms such that each farm has a number of commercial crops or livestock enterprises which are dependable sources of income.

# PROJECTIONS

The ways and means of increasing productivity and promoting profitability of farm enterprises can be chosen from a list of policy instruments which include the following:

(1) Input or price subsidies.

(2) Increased yields through improved husbandry and agronomy.

(3) Improved marketing facilities.

(4) Improved resource management.

(5) Resource base expansion to eliminate bottlenecks.

A combination of such policy instruments can be used to bring about diversification. A demonstration of a systematic procedure is shown in the following pages.

The first activities to be promoted are selected using the reduced cost list (Table 7). Then a policy instrument is decided on by referring to the shadow prices of constraining resources. The instrument which can expand the most limiting resource is then used. Alternative instruments which can increase the profitability of the selected activities without using additional farm resources should also be looked into. Also a combination of instruments can be worked out. Each policy instrument decided upon can then be incorporated into the model and its effect can be tested. The new solution may show whether the instrument is adequate

and if not, how it can be improved.

For demonstration purposes castor seed is used in this paper to show how such a crop can be promoted using economic incentives. Sensitivity analysis for this crop suggests that castor seed can be produced economically if its present price goes up 6 cents (from 33 to 39 cents) per kilogram. However it is also indicated that production of this crop is not likely to expand beyond a certain level unless there is more land available (Table 11, line number 57). Yet land breaking is limited by the high costs of tractor services. The implication is that further price increases may not have any effect within certain limits.

The validity of this interpretation was checked by using different policy instruments on castor seed. The procedure to promote castor is affected by including three more coefficients in the model as shown in Table 12. In order to show that the level of subsidy cannot change production of the crop beyond a certain limit, the subsidy is successively increased while other things are kept constant until it reaches the level of 90 percent of the net price. The resultant production of castor seed and total net revenue are shown in Table 13. The facts demonstrated in this table are that:

(1) a subsidy of 10 cents per kilogram of castor is enough to bring it into production, but at a very low level, the level indicated for a 6 cent change in Table 11,

# TABLE 11

## SENSITIVITY ANALYSIS OF ACTIVITIES WHICH ARE IN THE BASIC SOLUTION

| NUMBER | .COLUMN. | AT | ...ACTIVITY... | ..INPUT COST.. | ..LOWER LIMIT.<br>..UPPER LIMIT. | LOWER ACTIVITY<br>UPPER ACTIVITY | ...UNIT COST..<br>...UNIT COST.. | ..UPPER COST..<br>..LOWER COST.. | LIMITING<br>PROCESS. | AT<br>AT |
|---|---|---|---|---|---|---|---|---|---|---|
| 30 | PLANTN | BS | 2.00000 | 3.00000- | .<br>NONE | 2.00000<br>5.14950 | INFINITY-<br>88.10707- | INFINITY-<br>85.10707 | NONE<br>S.PLTN | <br>LL |
| 32 | POTATO | BS | 5.00000 | 11.20000- | .<br>NONE | .<br>9.86327 | 6.14756-<br>17.59479- | 17.34756-<br>6.39479 | S.GOAT<br>BREAKLS | LL<br>LL |
| 34 | COTT | BS | 7.90000 | 7.70000- | .<br>NONE | 7.40000<br>8.00000 | 5.41000-<br>18.95000- | 13.11000-<br>11.25000 | CASTO<br>LANDB | LL<br>UL |
| 39 | GOAT | BS | . | 40.00000- | .<br>NONE | .<br>5.00000 | INFINITY-<br>6.14756- | INFINITY-<br>33.85244- | NONE<br>S.GOAT | <br>LL |
| 47 | S.POTA | BS | 400.00000 | .80000 | .<br>NONE | .<br>789.06177 | .07684-<br>.21993- | .72316<br>1.01993 | S.GOAT<br>BREAKLB | LL<br>LL |
| 48 | S.VEG | BS | . | .70000 | .<br>NONE | .<br>13.55932 | INFINITY-<br>1.16376- | INFINITY-<br>1.86376 | NONE<br>VEG | <br>LL |
| 49 | S.COTT | BS | 474.00000 | 1.33000 | .<br>NONE | 444.00003<br>480.00000 | .09017-<br>.31583- | 1.23983<br>1.64583 | CASTO<br>LANDB | LL<br>UL |
| 50 | S.COFF | BS | . | 1.13000 | .<br>NONE | .<br>31.57892 | INFINITY-<br>1.14321- | INFINITY-<br>2.27321 | NONE<br>COFF | <br>LL |
| 51 | S.MAIZ | BS | . | .75000 | .<br>NONE | .<br>19.99998 | INFINITY-<br>.58446- | INFINITY-<br>1.33446 | NONE<br>MAIZE | <br>LL |
| 52 | S.SAVA | BS | . | .50000 | .<br>NONE | .<br>230.76920 | INFINITY-<br>1.69330- | INFINITY-<br>2.19330 | NONE<br>CASSV | <br>LL |

Table 11 Continued...

```
                                                                    INFINITY-   INFINITY-      NONE
53  S.PIG     BS      .        195.00000      .                      8.86593-   203.86593   PIG           LL
                                                    NONE    1.61751

                                                                    INFINITY-   INFINITY-      NONE
55  S.POLT    BS      .         10.50000      .                       .52316-    11.02316   FOWL          LL
                                                    NONE   21.49646

                                                                    INFINITY-   INFINITY-      NONE
56  S.BEEF    BS      .       1480.00000      .                     95.94403-  1575.94403   BEEF          LL
                                                    NONE     .04139

                                                                    INFINITY-   INFINITY-      NONE
57  S.ASTO    BS      .           .33000      .                       .05635-      .38635   CASTO         LL
                                                    NONE   47.99997

                                                                    INFINITY-   INFINITY-      NONE
58  S.WEAN    BS      .         20.00000      .                      5.90914-    25.90914   PIG           LL
                                                    NONE    2.43235

                                                             1.00000     .90167-     4.40167-   CASTO         LL
63  BLS-D     BS    4.00000     3.50000-      .              5.20000    2.17917-     1.32083-   BLS-A         LL
                                                    NONE

                                                            27.75000    1.44267-      .84267-   CASTO         LL
64  CSUBSDY   BS   29.62500      1.00000      .             30.00000    5.05333-     6.05333    LANDB         UL
                                                    NONE

                                                                    INFINITY-   INFINITY-      NONE
66  PSUBSDY   BS      .           .04000      .                       .05635-      .09635   CASTO         LL
                                                    NONE   47.99997

                                                             7.74388   14.45718-    74.45717-   S.GOAT        LL
68  TRACTSV   BS    3.87000     59.99999-     .              6.57519   37.63107-    26.36891-   BEEAXLS       LL
                                                10.00000
```

## TABLE 12

## COEFFICIENTS INTRODUCED INTO THE MODEL SO AS TO INCLUDE A SUBSIDY OF 30 CENTS ON CASTOR SEED

| | Price Subsidy | Production of Castor Seed | Sale of Castor Seed |
|---|---|---|---|
| Net Revenue | 0.30* | -0.20 | 0.33 |
| Land A | | 0.10 | 0.00 |
| Labour: January - April | | 10.00 | 0.00 |
| May - August | | 0.00 | 0.05 |
| September - December | | 5.00 | 0.00 |
| Capital Equipment | | 5.00 | 0.00 |
| Storage | | 0.00 | 0.05 |
| Transport | | 0.20 | 0.02 |
| Cash Cost | | 0.00 | 0.00 |
| Inventory | | 80.00 | -1.00 |
| Government Policy | 1.00* | 0.00 | -1.00* |
| Price | | 0.00 | 0.45 |

* The only coefficient introduced into the model for government policy.

## TABLE 13

## CHANGES IN THE NET REVENUE AND LEVELS OF PRODUCTION WITH INCREASING SUBSIDY LEVELS FOR CASTOR SEED

| Solution | Percentage of Subsidy | Real Subsidy Level (Cents/Kg.) | Net Price For Castor (Cents/Kg.) | Castor Seed Production (kgs) | Cotton Production (kgs) | Plantain Production (kgs) | Potato Production (kgs) | Net Revenue (shs) |
|---|---|---|---|---|---|---|---|---|
| 1. | 0.0% | 0.0 | 33 | 0.0 | 474.0 | 600.0 | 400.0 | 731.05 |
| 2. | 30.0% | 10.0 | 43 | 48.0 | 444.0 | 600.0 | 400.0 | 731.19 |
| 3. | 45.0% | 15.0 | 48 | 64.0 | 434.0 | 600.0 | 400.0 | 734.03 |
| 4. | 60.0% | 20.0 | 53 | 64.0 | 434.0 | 600.0 | 400.0 | 737.23 |
| 5. | 75.0% | 25.0 | 58 | 64.0 | 434.0 | 600.0 | 400.0 | 740.43 |
| 6. | 90.0% | 30.0 | 63 | 64.0 | 434.0 | 600.0 | 400.0 | 743.63 |

(2) net income remains almost unchanged, and

(3) further increases in subsidy have no effect.

The significance of these factors is that the effectiveness of a policy instrument may be limited by constraints which were not removed. In this case availability of tractor services is the obstacle as indicated in the sensitivity analysis of the six solutions which were obtained.

Another factor tested is the effect of increasing the profitability of one isolated farm activity. A combination of subsidy at levels of 15 cents and increased yield of 38 percent for castor are used. The results are that castor seed is the only cash crop that can replace cotton on a typical farm although the income level remains almost unchanged as shown in Table 14.

What one concludes from the above discussion is that a combination of commercial farm activities should be simultaneously promoted in order to widen farmer's source of income. Although the resulting net income levels may not be very high they may be more dependable than incomes from a single cash product. Table 15 shows a number of solutions using combinations of different policy instruments to promote castor seed. A number of other farm activities can be promoted in the same way so that there is more than one marketable product on the average farm in the region. Solution 3 in Table 15 offers a modest feasible diversification programme which makes the average farmer able to produce castor seed as an additional crop. If yields of castor can be increased

## TABLE 14

## POSSIBLE EFFECTS OF A PROJECT WHICH AIMS AT PROMOTING PROFITABILITY OF A SINGLE FARM ACTIVITY IN ISOLATION FROM ALTERNATIVE FARM ENTERPRISES

| | Before | After |
|---|---|---|
| Policy Instruments: | | |
| (a) Increased Yield | 0.0% | 38.0% |
| (b) Subsidy on Castor | 0.00 cents | 0.15 cents |
| Net Price Per kilogram of Castor | 0.33 cents | 0.48 cents |
| Total Production: | | |
| (a) Castor Seed | 0.0 kgs | 1,742.0 kgs |
| (b) Cotton | 474.0 kgs | 58.1 kgs |
| (c) Plantain | 600.0 kgs | 600.0 kgs |
| (d) Potatoe | 400.0 kgs | 400.0 kgs |
| Total Net Revenue | 731.02 shs | 753.13 shs |

NOTE: The result is that cotton is replaced by castor seed and the income level is virtually unchanged.

## TABLE 15

## SYSTEMATIC SELECTION OF POLICY INSTRUMENT TO ALLOW CASTOR SEED INTO THE OPTIMUM PRODUCTION OF A MODEL FARM OF BUGANDA REGION

| | Basic Solution | Solution 1 | Solution 2 | Solution 3 | Solution 4 | Solution 5 | Solution 6 | Solution 7 | Solution 8 |
|---|---|---|---|---|---|---|---|---|---|
| Castor Seed Yield Increase (kgs.) | 00.00 | 00.00 | 10.00 | 20.00 | 30.00 | 40.00 | 30.00 | 40.00 | 220.00 |
| Subsidy on Castor (shs.) | 00.00 | 00.30 | 00.15 | 00.15 | 00.15 | 00.15 | 00.15 | 00.15 | 00.15 |
| Limiting Factor | Price of Castor | Yield | Transport | Labour | Tractor | Tractor | Tractor | Tractor | Tractor |
| Suggested Policy Instruments | (a) | (b) | (c) | (d) | (a) | (e) | (e) | (e) | (e) |
| Effective Instruments | None | (a) | (a)(b) | (a)(a) | (a) (b) | (a) (b) | (a)(b)(c) | (a)(b)(c)(f) | (a)(b)(c)(d)(e)(f) |
| Net Revenue (shs.) | 713.00 | 744.00 | 738.00 | 742.00 | 751.00 | 800.00 | 753.00 | 822.00 | 2306.00 |
| Production Levels | | | | | | | | | |
| Cotton (kgs.) | 474.00 | 434.00 | 434.00 | 434.00 | 165.60 | 193.00 | 59.10 | 0.00 | 0.00 |
| Plantain[+] (kgs.) | 600.00 | 600.00 | 600.00 | 600.00 | 600.00 | 600.00 | 600.00 | 600.00 | 600.00 |
| Potatoes[+] (kgs.) | 400.00 | 400.00 | 400.00 | 400.00 | 400.00 | 400.00 | 400.00 | 400.00 | 400.00 |
| Castor Seeds (kgs.) | 0.00 | 64.00 | 72.00 | 80.00 | 1269.10 | 1252.60 | 1742.00 | 1827.00 | 1740.00 |

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[+] Level of potato production does not change because it uses soil "B" solely.

[+] Plantain is fixed at 600.0 Kilogrammes.

Key For Table 15

(a) = Subsidy on the price of castor seed

(b) = Increased yields for castor seed

(c) = Transport subsidy

(d) = Cheaper hired labour

(e) = Increased facilities on mechanical equipment for land breading

(f) = Improved storage facilities

breaking

by 25 percent, then a subsidy of 15 cents per kilogram can offer farmers enough incentive to produce the crop.

## COST ESTIMATES

The cost of implementing a diversification programme on an average farm can be estimated in the following way:

A. Cost to Farmer for a Single Crop Year

(1) Capital Expenses

| | |
|---|---|
| Breaking new land | 0.02 shs. |
| Machinery and equipment | 60.53 shs. |
| Storage Construction | 25.70 shs. |
| Sub-total | 85.25 shs. |

(2) Operating Expenses

| | |
|---|---|
| Material purchases | 87.65 shs. |
| Transport | 30.44 shs. |
| Tractor services | 110.20 shs. |
| Cash costs | 4.05 shs. |
| Sub-total | 241.34 shs. |

B. Cost to the Government

(1) Subsidy per Farm of 1.5 Hectares

| | Rate | Value |
|---|---|---|
| Cotton | 50% on capital | 27.13 shs. |
| Castor seed | 0.15 shs/kg | 80.00 shs. |
| Sub-total | | 107.13 shs. |

Total government expenditure on the project will depend on the number of farms in the region, acreage under subsi-

dized crops and the level of increase in yields which will be effected by the agronomical practices. It is therefore important to obtain such data beforehand for purposes of comparing this project with alternatives.

## DIVERSIFICATION ADMINISTRATION

Diversification anticipates use of existing Ministerial departments and units for implementing the programme. Farmers should be informed about new prices of subsidized crops through the extension service and various types of mass media. A government agent for buying and handling the crop should be established in the area. This agent could be licensed to execute the subsidy and to receive supporting funds from the government. The agent could also supply seeds to farmers at a price determined by the Ministry of Agriculture. The agronomical research unit would look into different ways of improving quality and yields of castor seed and the economic planning unit of the Ministry would be responsible for periodic evaluation of the project. Coordination of the project could be done through the Office of the Commissioner of Agriculture for Production. As the new crop pattern becomes integrated, cooperatives or private buyers can be encouraged to market the crop.

There is an export market for castor seed, but a home based processing industry for castor oil should be encouraged as well. After some years the new farming pattern may be able to carry on without government intervention, in which case subsidies will be phased out.

# CONCLUSIONS AND RECOMMENDATIONS

The linear programming technique is a useful method for analyzing a problem of insufficient diversification in agriculture and for arriving at policy programmes which can bring about diversity on a typical farm. The advantage of this method is to minimize public expense on such projects by determining the shortest route to the goal. It offers alternative approaches to diversification and it minimizes the possibility of degeneracy. The most profitable farm activities to be promoted can also be determined through this method. It makes it possible to test the economic effects of a policy instrument before actual implementation. Constant evaluation and adjustment of the instruments are facilitated by this technique.

Since the general economic structure in the cotton growing areas of Buganda cannot sustain lucrative specialization in farming, one way to improve incomes in the area is through improved overhead facilities.

It is also recommended that diversification projects should have a limited number of targets since too many targets are likely to defeat each other. Table 15 shows that if increased yield for castor was the only instrument in a project two targets would be incompatible; the targets are, increased farm income and diversified production.

Constant evaluation of the project is necessary in order to steer the course of the programme. The expected benefit from diversification is to enable farmers to widen the source of their incomes in a predictable and controllable manner.

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# APPENDIX I

## RESOURCE REQUIREMENTS AND ASSUMPTIONS FOR EACH ALTERNATIVE PRODUCTION ACTIVITY

### Plantain and Banana

Resource requirement for establishing a banana grove on a 0.1 hectare of land has been estimated as follows:

| | |
|---|---|
| Capital Equipment | - 0.50 shs |
| Transport Charge | - 2.00 shs |
| Cash Costs | - 0.50 shs |
| Total | - 3.00 shs |

The assumptions are that the only capital equipment which is used is a hand hoe, a knife and some planting material. The banana suckers can be obtained free from other farmers when thinning their plantations. A hoe and a knife costing 5.00 shillings can be used for some 10 years in which case its annual cost is estimated at 0.50 shillings.

Transport charges are estimated on the assumption that the required capital equipment and planting material are from a nearby source where a bicycle can be used. The 2.00 shillings have been arbitrarily set to account for such transport constraints. Cash cost include weavil killer and fertilizers which a farmer may use for a few plants in the grove.

Labour requirement is well spread throughout the year at an estimated rate of 0.2 man-day per season. Selling or harvesting can take place anytime of the year. Selling activity is also estimated to require labour at a similar rate.

The expected yield from a tenth of a hectare is 300.0 kilograms of plantain and 150.0 kilograms of bananas. Each kilogram is estimated to fetch a net revenue of two cents. No transport or storage facilities are required since traders usually buy plantain from the farm.

Plantain are grown on soil A while bananas are grown on soil type B. The former can be ready for cutting within a year but the latter can take up to 18 months before maturity.

Sweet Potatoes

Resource requirements for establishing 0.1 hectare of a sweet potatoe plant have been estimated as follows:

| | | |
|---|---|---|
| Capital | - | 6.00 shs |
| Transport | - | 5.00 shs |
| Cash cost | - | 0.20 shs |
| Total | - | 11.20 shs |

The assumptions are that in addition to the farm tools expense the farmer has to buy a spray pump at an estimated annual cost of 5.00 shillings. The cost of planting material is estimated at 0.50 shillings and another 0.50 shillings for the farm tools.

Tractor hire services may be required at a rate of 0.3 tractor hours for a 0.1 hectare plot. The cost of spray is estimated at 2.00 shillings per hectare.

Sweet potatoes can do well on soil B with an expected yield of 800.0 kilograms per hectare fetching a net revenue of 0.80 shillings per kilogram.

Labour estimates for planting and maintaining 0.1 hectare of potato is 5.0 man-days for each season of the year. Also from September to December 0.02 man-days are estimated for the selling activity.

Sweet potatoes take 9 months from planting to uprooting. Usually planting can be spread over a few weeks to allow extended harvesting period for the purpose of regulated food supply. That way labour requirement for a single crop can be evenly spread over the year especially when the plot is large.

No transport constraint is envisaged because potatoes can be bought from the farm by traders or they can be sold by the road-side near the farm.

## Vegetables

Resource requirement for establishing a 0.1 hectare of vegetable on land type A are estimated as follows:

| | |
|---|---|
| Capital Equipment | - 6.00 shs |
| Transport Charge | - 5.00 shs |
| Cash Costs | - 0.50 shs |
| Total | - 11.50 shs |

Capital equipment includes one pump spray of 5.00 shillings annual cost, and 1.0 shilling worth of farm tools. Transport costs are used for getting the equipment, seeds and spray to the farm. Cash costs include 0.25 shillings worth of seeds and 0.25 shillings worth of spray.

A minimum of 0.3 tractor hours at a cost rate of 60.00 shillings per tractor hour are needed to break the land. A lot of labour is required for weeding and harvesting as well as for selling. Transport is high too because farmers cannot usually dispose of their vegetables except by taking them to some urban markets. Transport cost for the selling activity are estimated at 0.15 shillings a kilogram and there is an expected loss of 10 percent during transporting and market handling.

Labour requirement is estimated at 15.0, 20.0 and 5.0 man-days for the three periods of the year, respectively. Harvesting and selling takes place in the first two periods at an estimated labour requirement of 0.12 man-days for each kilogram sold.

The expected yield of vegetable is 400.0 kilograms per hectare and the average price is 0.70 shillings per kilogram. Vegetables include different varieties of tomatoes, greens, onions and cabbages, excluding Irish potatoes.

## Cotton

Cotton tends to be the major cash crop for which most attention of the farmer is paid. Once it is established

in the field the only type of expenses from the farmer is for spraying against pests. Weeding is done by hand. However spraying chemicals for cotton are subsidized such that only 2.00 shillings per hectare can suffice.

A lot of labour is needed for picking and sorting as well as packing lint before it is marketed. March and April are the planting months during which 120.0 man-days are estimated per hectare for cotton. Another 2.0 man-days for thinning and weeding are spread over the growing period while 12.0 man-days in the last months of the year are required for harvesting and preparing the crop.

Annually 7.5 shillings for capital equipment are required to buy farm tools, containers and spray equipment. No transport costs are envisaged since most farm inputs can be obtained within walking or cycling distances of most farms. Seeds are distributed free by the Department of Agriculture.

Tractor services are estimated at 3.0 tractor hours per hectare of land type A before seed bed can be made. The cost of hiring a tractor is 60.00 shillings per hour. This cost is arrived at using 1972 rates for the government tractor service unit in the country.

The expected yield is estimated at 600.0 kilograms per hectare and the price is 1.40 shillings per kilogram. The transport cost during selling activity is estimated at 0.20 shillings per kilogram. Also 0.50 shillings are estimated for storage. The net income is 1.33 shillings per

kilogram.

During the selling activities 0.02 man-days of labour are required per kilogram and the selling activities are confined to one season unlike some other products.

## Coffee

Required farm inputs for a hectare of coffee include 90.00 shillings of cash costs; 80.00 of which is for capital equipment and 1.00 shilling for buying planting material at an estimated rate of 2 cents per tree. No transport cost is required for the production activity of coffee since most inputs are locally available.

Most labour goes into weeding, pruning, picking and sun drying coffee berries. Picking starts in December but drying depends on the availability of sunshine and the weather during the first months of the year. Picking and drying berries therefore spreads labour requirement over the year with a peak in the last months.

A coffee crop takes up to 18 months before maturity. The assumption over this aspect is that once the crop has been established the farmer can count its value as the expected net return for its first yield. This yield is estimated at 500.0 kilograms per hectare. Normally it is expected to increase over a period of years and reach a peak of 800.0 kilograms per hectare. The crop has a productive life time of 18 to 20 years.

To accommodate the time aspect in the model 0.20 units

have been added to every kilogram sold so that the selling activity for coffee has a 20 percent constraining weight per kilogram as a disadvantage over other production enterprises which can be completed within a period of 12 months. This deliberate appendage makes coffee less competitive with other annual crops.

The price of coffee is 1.20 shillings a kilogram, out of which the farmer has to pay 5 cents for transport and 2 cents storage facilities. Labour requirement for selling activity is estimated at 0.04 man-days per kilogram.

## Maize

Estimated resource requirement for 0.1 hectare of maize on land type A are as follows:

Capital Equipment - 3.00 shs.
Transport Charge - 5.00 shs.
Cash Cost - 1.00 shs.
Total - 9.00 shs.

Capital equipment includes farm tools and containers. Transporting farm equipment and seeds to the farm takes 5.00 shillings. Purchase of seeds is estimated at 1.00 shilling.

Labour requirement is estimated at 15.0, 10.0 and 5.0 man-days during the three periods respectively. 0.3 hours of tractor hire service at a cost of 60.00 shillings per hour to break the land are also estimated.

Yield of maize (without the cob) is 500.0 kilograms per hectare. The net price is 75 cents a kilogram and there

is a 5 cent worth of storage for every kilogram sold. No transport cost for selling because most of it can be sold through traders who fetch it from the farm. Most maize is sold in April and December months at an estimated rate of 0.01 man-days per kilogram for labour requirement.

## Cassava

Cassava is considered the least demanding crop for labour and capital expenses. However it is not a popular food crop in the area either.

The estimated resource requirement for a tenth of a hectare cassava crop is as follows:

Capital Equipment - 3.00 shs.
Transport Charge - 5.00 shs.
Cash Cost - 1.00 shs.
Total - 9.00 shs.

Capital equipment includes farm tools and containers. Transporting planting materials costs 5.00 shillings and 1.00 shilling is needed for purchasing the cuttings.

Labour requirement for planting, weeding and harvesting is estimated at 10.0, 8.0 and 12.0 man-days for the three periods respectively. Breaking 0.1 hectares of land type B requires 0.3 tractor hours at a cost rate of 60.00 per tractor hour. Selling activity takes time all year round at an estimated rate of 0.15 man-days per kilogram.

The yield of cassava is expected at 600.00 kilograms per hectare. Selling activity requires transportation at a

cost of 10 cents per kilogram. There is also an expected loss of 30 percent during harvesting and handling. Net price is 0.20 shillings per kilogram.

## Pigs and Weaners

A farmer can obtain a female weaner at a cost of 20.00 shillings and spend 15.00 shillings on both transport and constructing a barn. He can also feed the animal at a cost of 220.00 shillings, during the year. He can also use other food wastes for supplementing feeds for the animals.

By the end of the twelve months the farmer has an estimation of 1.33 fat pigs and two weaners for sale.[1] His labour is evenly spread throughout the year at an estimated rate of 10.0 man-days per four month period. These animals can occupy 0.05 hectares of land B and other maize which can be pro-

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[1] 1.33 of a fat pig was arrived at by assuming the following:

(a) A seven week gilt is purchased and raised for 160 days. The average daily gain is 0.45 kilograms when the gilt is fed on young maize and cassava cake and partly scavenging.

(b) The gilt is bred at the age of seven months and its gestation period is 114 days.

(c) A litter of four piglets is expected following a 60 day weaning period taking into account mortality.

(d) By the end of 334 days (274 + 60) four piglets are available. Two of them are sold while the other two are fattened for another 210 days. By the end of 15 years there should be two fat pigs plus a sow on the farm but within one year there is (2 ÷ 1.5) 1.33 fat pigs for sale. The sow is kept for further breeding.

duced on 0.05 hectares of land A and cassava from 0.05 hectares of land type B.

The net price for a weaner is 20.00 shillings and for the fat pig is 195.00 shillings. It is assumed that within a year a litter of piglets will be produced out of which four can survive. The farm can then sell two of them and fatten the other two for sale as pork.

Selling activities are estimated to require 0.03 man-days of labour which can be used any time of the year at the farmer's convenience. A 0.01 man-day is therefore allowed per period for each sow sold. Also a 5.00 shilling cost on transporting the animals is expected.

## Goat

A goat is the most hardy farm animal in the environment of the cotton growing areas of Buganda. With 20.00 shillings a young goat can be obtained requiring 15.00 shillings for housing and transport facilities. The goat can be grazed on 0.1 hectares of land type B and also be fed on food wastes. However by the end of the year there will only be an estimated fraction of 0.9 of a goat for sale. Five shillings for veterinary care is estimated as a cash cost and the net price of a live goat is expected to be 100.00 shillings. It will also require 5.00 shillings of transport and 0.03 man-days of labour for the selling activity.

## Poultry

Resource requirement for a 50 bird poultry production unit is estimated as follows: 390.00 shillings of total cost which includes 170.00 shillings for capital cost, 15.00 shillings for housing construction, 5.00 shillings for transporting the birds to the farm and 200.00 shillings of feeds throughout the year.

A minimum of 50 young birds are purchased at a rate of 2.50 shillings per bird. Feeding and watering equipment are included in the capital equipment value of 45.00 shillings. Out of the 50 birds bought 10 are expected to die, such that by the end of the year only 40 birds are available for selling at a net price of 10.50 shillings each. Also 0.50 shillings worth of transportation is required per bird sold.

## Beef Cattle

Resource requirements for beef cattle are taken as follows: 720.00 shillings total cost which includes 80.00 shillings for the purchase of a calf, 10.00 shillings for constructing the shed, 10.00 shillings for transporting the animal and equipment to the farm and 600.00 shillings for feeds and veterinary services.

One unit of beef cattle is estimated to require 0.1 hectare of land A and 0.25 hectares of land B both for grazing and housing purposes. Labour requirement is uniform throughout the year at an estimated rate of 30.0 man-days plus 0.03 man-days for the selling activity.

It is assumed that beef animals take two years before reaching marketing age. In this model only 0.5 of beef cattle unit is considered available at the end of the first year. The net price of a two year old beef animal is estimated at 1,480.00 shillings and its selling cost is 20.00 shillings for the transport charges. Both production and selling activities have no particular season to restrict labour.

## Mixed Crops Maize and Vegetables

Resource requirements for mixed vegetables and maize as a single production activity are estimated as follows: 12.00 shillings total cost including 6.00 shillings of capital cost, 5.00 shillings for transport and 1.00 shilling for seeds.

Breaking 0.1 hectares of land type A requires 0.3 tractor hours. Labour requirement is estimated at 17.0, 11.0 and 13.0 man-days for the three periods of the year, respectively.

Yield is expected at 20.0 kilograms of vegetables and 25.0 kilograms of maize and the selling prices will be as shown in the respective columns for vegetable and for maize.

## Hired Labour

To hire labour an estimated cost of 3.50 shillings per one man-day for any of the three seasons is required. Labour can be hired in as much as it contributes positively to the

net revenue.

## Mixed Crops Maize and Potatoes

Resource requirement for mixed maize and potatoes for 0.1 hectares of land type B are as follows: 12.00 shillings of total costs which includes 6.00 shillings for capital equipment, 5.00 shillings of transport and 1.00 shillings for maize seeds planting material for potatoes in this activity can be obtained from last year's crop or from local supply for free.

Labour requirement is 5.0, 5.0 and 10.0 man-days for the three periods, respectively. Breaking land needs 0.3 tractor hours at a cost of 60.00 shillings per hour.

Yield is expected at half that of the respective pure crops of maize and potatoes. When the two crops are mixed yield is 400.0 kilograms of potatoes and 250.0 kilograms for maize per hectare.

## Castor Seed

Resource requirements for 0.1 hectares of castor seed on land type A are estimated as follows: 3.40 shillings of total costs which includes 3.00 shillings for farm tools, 20 cents for transport and 20 cents for seeds.

Labour requirement is confined to the wet period of the year at an estimated amount of 10.0 man-days in February and March for land preparation, sowing and weeding. Harvesting can take place in the last months of the year at an esti-

mated rate of 5.0 man-days in total.

Yield is 800.0 kilograms of dried castor seed per hectare. The net price is 0.33 shillings per kilogram and it requires 0.05 man-days to market it. Storage and transport costs per kilogram are estimated at 5 and 2 cents respectively per kilogram.

### Cotton Subsidy

There is an estimated 50 percent of subsidy on farm inputs for cotton. Seeds, tools, spray pump and implements for cotton are obtainable at subsidized prices throughout the country. This subsidy alleviates capital constraint.

### Breaking Land Types A and B

The inclusion of land breaking activities in the model is to enable the farmer to allow expansion of land beyond 1.5 hectares if it is profitable to do so. It is assumed that most farmers in Buganda can expand their present acreage at the following estimated levels of resource use: At least 5.00 shillings for the purchase of hand tools, 7.5 man-days and 2.0 tractor hours for breaking one hectare of land type A. Land B requires twice as much labour and tractor hours with 5.00 shillings worth of tools per hectare.

# APPENDIX II

## DESCRIPTION AND ASSUMPTIONS OF ROWS

### Net Revenue

The objective function shows marginal costs and net prices to the farmer for each alternative farm activity. On the production side it shows the cost of recurrent costs and capital investment which have to be incurred in order to establish and maintain a tenth of a hectare of a crop, or a unit of livestock. The amount produced multiplied by the marginal cost gives the total cost of production for the activity. On the selling side the objective function shows the net price per unit receivable to the farmer after accounting for the cost of marketing. Products like weaners and bananas are bought on the farm and they do not have storage requirement so that their gross price is the same as net price. In a good farming year an income of 1,000.00 shillings can be obtained from a farm of 1.5 hectares in the cotton growing regions.

### Land Types A and B

A typical farm plot in Buganda region is on a hill side or a ridge the upper parts of which are usually thin, eroded and rain leached soils. Fragment quartzites are

also more exposed in the upper parts of the ridge. As one goes down the slope soils become deeper and richer. Lower parts have more fertile soils and easier to till than the upper one. Hence two types of land are recognizable; type A in the lower parts and type B in the upper part. There are crops like cassava, potatoe and grass for grazing which do well on type B soil and there are others such as cotton maize and vegetable which can only do well on the richer soil. Farm houses can be constructed on the upper land and use lower land for crops.

Usually there is land for expansion but the factors which limit the size of farms in this area are the seasonal labour bottlenecks, thick bush which cannot be moved with the tools farmers have, low yields which are aggravated by low net prices to the farmer and the difficulty of timing rain seasons.

## Labour

In most rural areas of Buganda region farmers do farm work for about three hours each working day. Cultivating is just one of the every day activities of a farmer and his family. A lot of labour goes into composing food and fuel as well as water for daily use.

It was estimated that there are three major crop seasons in the year during which different amounts of labour is available due to non-economical factors.

There is a difficulty of estimating the amount of

labour required per unit of activity such as selling one kilogram of a crop. It is also not easy to make a precise season in which the product is to be sold especially to non-seasonal products such as banana, cassava, and livestock. In the region selling activity for such products takes place any time of the year depending on the convenience of the farmer. It is therefore assumed that most items will take 0.01 man-days to be sold for the items which can be sold at any time of the year. This amount of labour requirement is repeated for all seasons to reflect the absence of seasonality while at the same time their encroaching on labour resource is accounted for. However some selling activities require more time when the farmer transports the item to the buyer. This is reflected in selling minor crops such as castor seed for which buyers are distances away. Selling bananas require more labour per kilogram than do other crops because of the market arrangements a farmer may have to make first before buyers can come to get bunches of bananas from the farm. All labour requirement for the selling activities is only meant to reflect seasonality or relative intensity but no attempt has been made to estimate exact requirement per unit sold from the farm.

### Capital Equipment

Cost of capital equipment have been roughly estimated for each alternative production activity. For crops it includes purchase of seeds, farm tools, spray equipment,

containers and any agro-chemicals. For livestock capital equipment includes purchase of the young animal or bird, watering equipment, food containers, farm tools, wheel barrows, heating system for chicken and other general purpose farm equipment.

The maximum amount the farmer can spend on capital investment is 150.00 shillings except in the case of credit or subsidy of some sort.

## Housing and Storage

No storage is used for any crop during production. Cotton, coffee and maize need storage facilities between harvesting and selling while being sun dried, sorted and packed or when just awaiting delivery. Other crops like banana, cassava and vegetables have to be sold as soon as they are harvested.

All animals require shelter and fencing. A large part of the construction is made from local material; roofing and barbed wiring or chicken mesh have to be purchased. These account for the expenses allocated into the housing row.

## Transport

In the production activities transportation costs are expected to be used for getting some of the purchased capital equipment which includes planting material. However there is a number of items which a farmer can obtain from

a walking distance. Else such items can arrive to the farm on a bicycle in which case no direct transport costs are accounted for. Cotton and coffee planting material and seeds are usually obtainable at no transport costs. A few other items are purchased from the farm by traders who drive big trucks, in which case farmers do not pay for their marketing transport. Bananas, sweet potatoes and weaners are sold in this way, whereas coffee, cotton and other minor crops have to be transported at the farmer's expense for marketing. Vegetables are often transported to the urban markets but in some cases they can as well be sold on the farm when buyers come to buy other crops like sweet potatoes or bananas.

Farmers usually sell their crops out of need for cash in which case when they need to sell their farm products they have no adequate cash at hand for transportation either. Those who cannot haul their products on bicycle have a great transport constraint on their production decision.

### Cash Costs (or Recurrent Cash Costs)

The row for recurrent cash cost is mainly to account for the type of expenses which a farmer has to incur while his product is still on the farm in its gestation. These usually cover cost of feeds for animals and chickens. Practically no money is spent on crops once they are established into the soil. Any expenses needed for crop production is

included in the capital equipment row. However on the understanding that some labour can be hired for weeding and harvesting some of the crops have a token cash cost of either 20 cents or one shilling to account for these expenses. Often this kind of labour is paid for in some amount of food equivalent whose value can be estimated. No cash cost is expected under the selling activities.

## Inventories and Price or Value of Production

Each product has an inventory row which accounts for the physical amount of the product expected from a tenth of a hectare plot. Under selling activities inventory rows show that one unit of the available amount is sold off the farm at a particular price. For the crops inventories are in kilograms, animals are per head and for poultry per chicken.

The value of production is virtually the price per unit which a farmer produces and sells. It includes marketing expenses particularly storage and transport costs.

## Government Intervention

The row marked Government accounts for any government policy which affects any particular activity such as cotton production is affected by the government subsidy. The policy can be per hectare, per unit produced or even per unit of any other constraining resource. An introduction of a government policy has to be accounted for by this row

under the appropriate column such that the particular product is affected directly. If the policy is a general one for all farm activities it can be either shown under each activity column or just for the constraining resource it is meant to alleviate.

# APPENDIX III

## SOME OF THE PREVIOUS AGRICULTURAL DIVERSIFICATION PROJECTS FOR THE COUNTRY

### Cattle Ranching Scheme

This project was designed for the grass land areas of West, Central and Eastern parts of the country. Government ranches are stocked with exotic cattle as well as cross breeds of indigenous and other type of cows. The area is supplied with water, fencing equipment, disease and pest control facilities. Individual ranchers are assisted to develop and maintain private ranches in those areas.

### Seed Multiplication Scheme

There is a scheme for increasing the availability of seeds for various crops in the country including Irish potatoes, different grains and pulses. Proven seeds are distributed to farmers just before the planting season. Farmers are expected to sell a certain quota of the crop to the government agency. This quota is used as seed reserve to be redistributed in another planting season. That way farmers in different areas are able to obtain seeds of crops which are traditionally confined to one area or seeds which are newly introduced. The scheme operates in

different areas of the country.

## Irrigation Scheme

There are quite a number of irrigation schemes all over the country in areas with inadequate rainfall but with rivers and fertile soils. In the Eastern region some citrus plantations are produced under this scheme, thus combining both citrus fruits production and irrigation schemes in a complementary form.

## Citrus Fruit Scheme

The government developed a number of citrus orchards in the Eastern region and some drier areas of the West. Extensive acreages of various citrus fruits are maintained for purposes including experimentation and propagation of fruits.

## Wheat Growing Scheme

There is one government financed wheat farm in Uganda being maintained by the Ministry of Agriculture in the extreme Eastern part of the country. It is in one of the few areas which have a flat topography and a high altitude (over 4,000 feet) which moderates tropical temperatures. The area is also on the leeward side of the Mountain Elgon where relief rainfall comes at the right time of the year to warrant wheat growth and the use of a combine in this part of the country.

## Sugarcane Outgrower Scheme

In the South-east of the country where privately owned large scale sugar plantations are located, small scale farmers are assisted to grow sugarcanes and sell them to the sugar manufacturers so as to enable such farmers to compete fairly with the larger plantations. Similar schemes exist in the North too for tobacco growers.

## Rice Scheme

There is a rice scheme developing in Central and Eastern parts of the country for the purpose of increasing rice production and propagating the idea of swamp reclamation.

## Kigezi Vegetable Scheme

In the extreme South-west corner of the country a scheme to promote vegetable production and marketing is carried out by assisting farmers to obtain right farm inputs at the right time and to give extension services and information on new farm inputs.

Some other Proposed Projects for Diversification in other parts of the country by the Planning Unit of the Ministry of Agriculture and Animal Resources are just listed here:

(1) Commercial Dairy Farming Development Project. April, 1975.

(2) Kenaf and Jute Development Project. April, 1975.

(3) Agricultural Zones Diversification Project. 1974.

(4) Proposal for the Purchase of 1,000 Tractors. December, 1972.

(5) Agricultural Credit Provided by the Uganda Development Bank.

(6) Gum Arabica Development Project.

(7) Cocao Development Project.

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